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Influence of Age on Alertness and Performance during 3-day cross North-Atlantic Operations

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SUMMARY

From literature it is known that a relationship exists between age and pilot's performance. Furthermore age correlates with shorter sleep, impaired sleep quality, difficulty in adapting to irregular work schedules and rapid time zone transitions. These factors may aggravate the effect of age and lead to impaired performance during flight duties.
Data from North-Atlantic operations (59 pilots) were used to investigate the relationship between age and alertness and performance during long haul operations. Pilots were equipped with a palm top computer and an actigraph for subjective and objective measurement of quantity and quality of sleep, alertness, and performance on a vigilance dual-task.
During the entire operation, no differences were found on subjective alertness between the younger and older pilots. Vigilance and tracking performance profiles appeared to be similar for both groups. Vigilance performance of older pilots was better after waking up and during the inbound leg. However, tracking performance of this group was worse before bedtime at stopovers and during the inbound leg. Performance was significantly correlated with age, but when correcting for baseline performance (home base), significancy almost disappeared.
It was concluded that, although performance of older pilots impaired more during the outbound flight as compared to younger pilots, sleep quantity and quality during the stopover night were sufficient to made them recover, and to perform at an adequate level on the return flight.

INTRODUCTION

The cognitive functions generally assumed to be important to the proper performance of in-flight tasks (1,2,3,4,5) are:

- perception (e.g. instrument monitoring)
- memory (e.g. remembering information given by air traffic control)
- problem-solving and decision-making (e.g. diagnosis of faults and defects)
- psychomotor coordination (e.g. flight control).

It is also assumed that more general cognitive functions, such as attention, concentration, and information processing speed, become more important with increasing age.
Furthermore, it is known that aging correlates with shorter sleep, impaired sleep quality, difficulty in adapting to irregular work schedules and rapid time zone tran-

sitions (6,7,8). These effects may aggravate the effects of age on pilot's performance and lead to impaired performance during flight duties (9,10,11).
For the most part, data on the effects of ageing on cognitive functions are obtained from studies in which the research population consisted of non-pilots (12,13,14). Only a limited quantity of literature is available on pilots. Since pilots are selected for these above-mentioned faculties, it is not right to generalise on the basis of data obtained from non-pilot populations.
As data from an earlier study on the effects of a controlled in-flight rest on North-Atlantic operations (15) were available, these data were used to investigate the relationship between age, alertness and performance, and to analyse the possible co-related effects of sleep during the trip.

METHOD

Subjects
The study included 59 pilots (30 captains and 29 first officers) flying on Boeing 747-300 operations, who were executing regular trips within their regular duty roster. Subjects were divided into two age groups; the younger pilots (n=34, mean 32.1, range 23-39 years) and the older pilots (n=25, mean 46.4, range 40-57 years). Mean total flight hours for the young group was 4955 (range 2.000-9.200) and for the older group 11.640 (7.000-17.000).

Trip characteristics
Measurements were made on 3-days North Atlantic trips involving Boeing 747-300 operations with a 3-person cockpit crew (Cpt, FO, FE). All outbound flights were executed during daylight and all inbound flights during the night. Stopovers included a time period of 22-25 hours from the afternoon on the day of arrival till the afternoon or evening the next day.

Assessment methods
Specific measures were chosen to evaluate sleep, alertness, and performance. Pilots were equipped with a Psion-3a palmtop computer to log subjectively estimated duration of sleep, sleep latency, total sleep time. Objective sleep data was recorded using an actigraph device. Using the event button, subjects marked beginning and end of sleep periods. In addition, the quality of sleep during the pre-trip night (at home) and the stopover night was assessed (16).
The Stanford Sleepiness Scale (17) was used to assess subjective alertness throughout the trip (Table 1). This subjective rating scale has proven to be sensitive in detecting any significant increase in sleepiness or fatigue.

Furthermore SSS measures showed to be highly correlated with flying performance and threshold of information processing speed during periods of intense fatigue (18).

Table 1: Stanford Sleepiness Scale (SSS)

1. Feeling active and vital; alert; wide awake
2. Functioning at a high level, but not at peak; able to concentrate
3. Relaxed; awake; not at full alertness; responsive
4. A little foggy; not at peak; let down
5. Foggy; beginning to lose interest in remaining awake; slowed dow.
6. Sleepy; prefer to be lying down; fighting sleep; woozy
7. Almost in reverie; sleep onset soon; losing struggle to remain awake

The performance task used in this study (VigTrack; Fig.1) was a dual-task, which measures vigilance performance under the continuous load of a compensatory tracking task (19). This task was successfully applied in studies on the effects of irregular early reporting times on alertness of pilots in short-haul operations (20), sedative effects of antihistamines, and alcohol (21,22). The VigTrack probes two important aspects of the behavioural capability of aircrew, and is not a measure of overall operational performance. However, high levels of performance on the VigTrack require sustained attention for 5 minutes, while attention is distracted by the tracking task. To the extent that attention and adequate tracking are critical features of many tasks involved in the safe operation of aircraft, the VigTrack data provide information about operational readiness and vigilance.
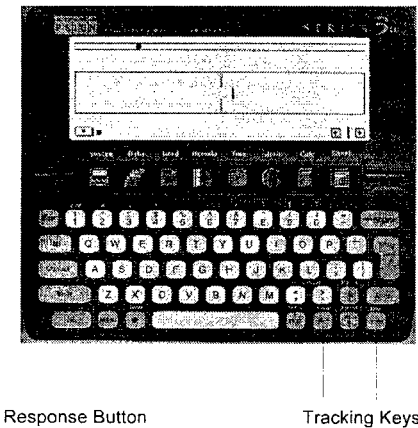

Response Button   Tracking Keys

Fig. 1. Psion 3a: Vigilance and Tracking task (VigTrack)

Procedure and experimental design

A schematic overview of the procedure is presented in Table 2. Before the trip, pilots were instructed how to use the actigraph and the Psion-3a palmtop computer. They were trained on the performance task and briefed on the subjective rating procedures. Each pilot was equipped with his own actigraph and Psion-3a. During the outbound flight, test sessions were performed just before and circa ¼ hour after the cockpit rest, and half an hour before top of descent. All sessions included SSS and VigTrack. The test procedure during the inbound flight was identical to the procedure applied on outbound flights. After their return at Amsterdam, actigraph and Psion-3a were collected and data were downloaded in a database.

Table 2: Test procedure: GSQS: Groningen Sleep Quality Scale; SSS: Stanford Sleepiness Scale; VigTrack: vigilance and tracking task.

Before Trip	
Pre-flight	instruction and training on task
	sleep data / GSQS / SSS / VigTrack
Outbound	
Pre-Rest	flight data / SSS / VigTrack
Post-Rest	SSS / VigTrack
Top of Descent	SSS / VigTrack
Stopover	
Before sleep	SSS / VigTrack
After Sleep	sleep data / GSQS / SSS / VigTrack
Inbound	
Pre-Rest	flight data / SSS / VigTrack
Post-Rest	SSS / VigTrack
Top of Descent	SSS / VigTrack

RESULTS

Age and alertness

No relationship was found between age and subjective alertness. During the entire trip, alertness profiles were comparable for younger and older pilots (Fig. 2). On average, both groups rated themselves as 'functioning at a high level' (score = 2) and 'relaxed awake' (score = 3) before and during the outbound leg. Before going to bed at the stopover hotel, they felt 'slowed down' (score = 5) and 'sleepy' (score = 6). The next day, they were not fully recovered, as compared to home base, but remained 'relaxed' and 'responsive' throughout the inbound leg (score = 3).
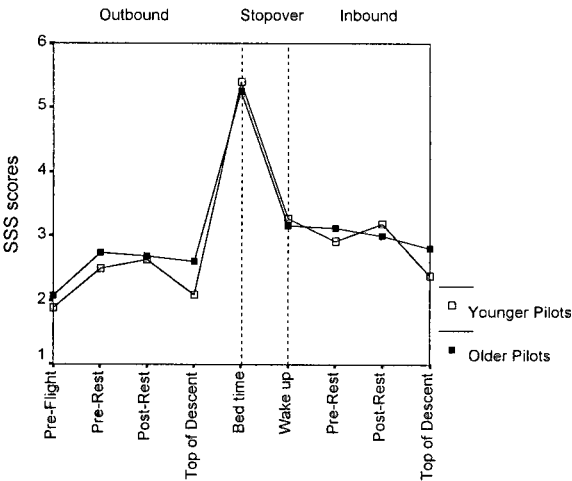

Fig. 2. Mean alertness scores (SSS) for younger and older pilots during the entire trip.

Age and performance

Performance profiles for the vigilance component (% omissions) of the VigTrack task appeared to be similar for the two groups (Fig. 3). Overall, younger pilots performed significantly better on the vigilance task than older pilots (F(1,488) = 60.97, p<.001). However, this difference disappeared when correcting for baseline (pre-flight) values. Analysing these differences scores, younger pilots showed a greater, but not significant, deterioration during the trip than older pilots; they performed better during the outbound trip but worse during the return flight.
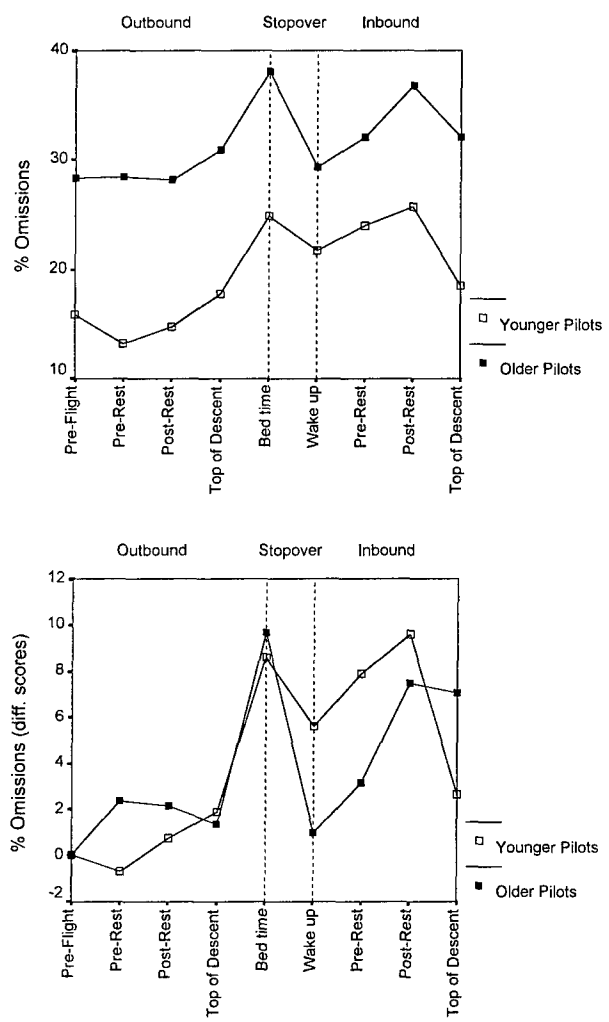
Fig. 3. Mean vigilance scores (% omissions): absolute scores (upper panel) and difference scores (lower panel) for younger and older pilots during the entire trip.
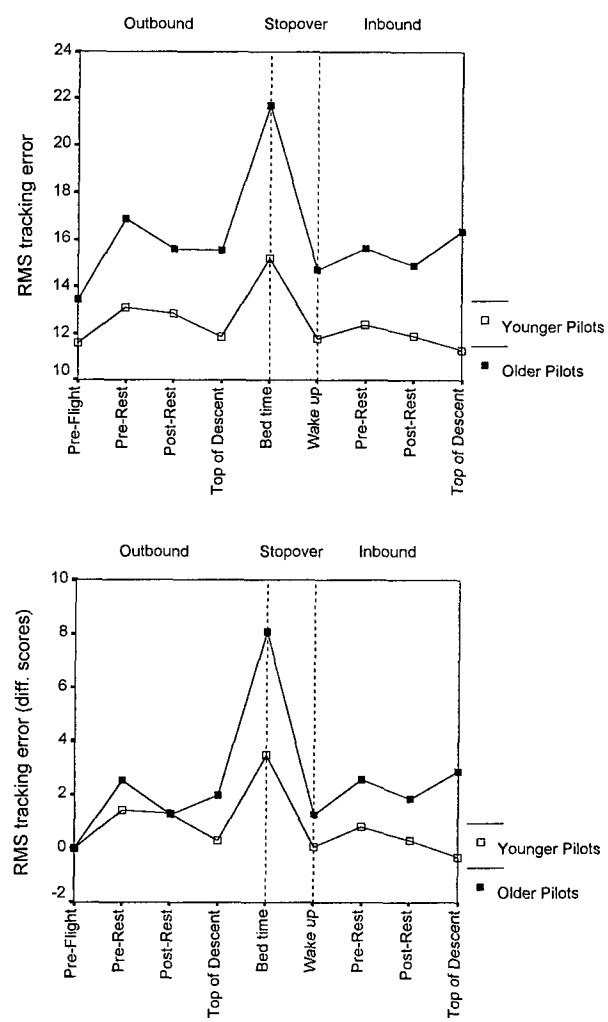

Fig. 4. Mean tracking scores (RMS): absolute scores (upper panel) and difference scores (lower panel) for younger and older pilots during the entire trip.

Performance profiles for the tracking component (RMS) of the VigTrack task were similar for both groups (Fig. 4). Overall, older pilots performed significantly worse $(F(1,488) = 42.28, p<.001)$, also after correcting for baseline values $(F(1,488) = 13.91, p<.001)$. This difference was most significant during the inbound leg $(F(1,219) = 8.81, p<.003)$. Tracking performance (difference scores) of older pilots tended to deteriorate from the stopover night until top of descent of the return flight, while younger pilots remained at baseline level (t = - 1.89, p < .065 resp. t = -1.71, p < .094).

The correlation between vigilance and tracking performance and age was computed using regression techniques. In table 3 regression coefficients and regression equations are given. Although a significant linear relationship was found between age and vigilance performance, the linear model explained only 9% of the variance. Tracking performance was clearly affected by age, and the scores presented in Fig. 5 (upper panel) suggested that age-related changes might contain a curvilinear component.

Regression analyses indicated that a curvilinear (cubic) model explained significantly more age-related variance (33%) than did a linear model (29%). Using both parameters (% omissions and RMS tracking error), standardized predicted values were calculated and overall performance was fitted in relation to age (Fig. 5, lower panel). Here too, a cubic model explained significantly more age-related variance (40%) than did the linear model (37%). Furthermore, this composite score explained significantly more variance (+9%) than did the model using only the tracking component.

Table 3. Regression coefficients and model equations; linear model for % omissions, cubic for RMS and standardized predicted values. †: variable not in the equation

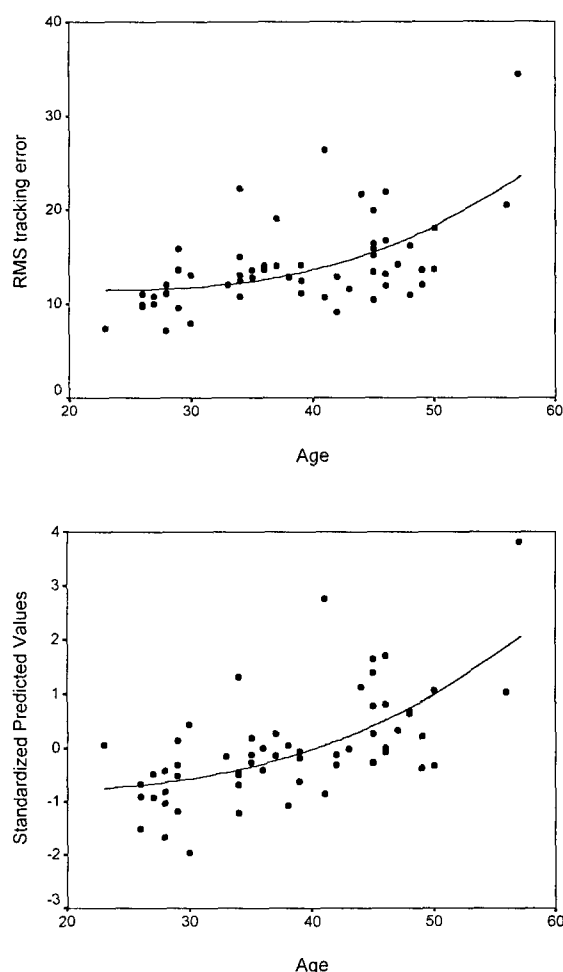|	R^2	p<	Age*B	Age*B^2	Age*B^3	const.
Vigilance % omissions	.091	.012	.494			6.634
Tracking RMS	.326	.001	†	-.00583	0.0162	12.608
Vig. & Tracking Std. pred. values	.402	.001	†	-.00046	2.3E-05	-.788

Fig. 5. Regression lines: tracking error (upper panel) and standardized predicted values (composite score, % omissions and tracking; lower panel) plotted against age and fitted with a cubic model.

Sleep at home and during stopover

All subjects considered themselves to be good sleepers when at home. Overall, no significant differences were found between younger and older pilots with respect of the various sleep parameters (Table 4). The night at home, before the outbound flight, sleep quality of younger pilots was slightly better, and total sleep time tended to be longer. During the stop over night, sleep latency of younger pilots appeared to be somewhat shorter, and older pilots tended to sleep longer as compared to home base. No significant correlations were found between age and the various sleep parameters.

Table 4. Mean scores on sleep quality, latency, and total sleep time, for younger and older pilots at home and during stop over nights.

	quality	latency (min)	total sleep time (min)
Home base			
younger pilots	1.9	26.7	457
	(2.4)	(40.1)	(77)
older pilots	3.0	25.5	420
	(3.8)	(36.6)	(85)
Stopover			
younger pilots	3.2	14.7	462
	(3.5)	(13.6)	(98)
older pilots	3.4	25.2	465
	(2.6)	(34.7)	(87)

CONCLUSIONS AND DISCUSSION

Using subjective and objective data from 3-day cross North-Atlantic operations, the influence of age on alertness and performance was investigated, and the possible co-related effects of sleep during the trip were analysed.

During the entire operation, alertness profiles of younger and older pilots showed great similarity; both groups rated themselves as 'functioning at a high level' during the outbound flight, 'sleepy' before going to bed at the stopover hotel, and 'responsive' during the inbound flight.

Vigilance and tracking performance profiles were similar for both groups during the entire trip, but younger pilots performed significantly better. When correcting for baseline levels, vigilance performance was not affected by age, but, as compared to younger pilots, tracking performance of older pilots tended to deteriorate from the stopover night until top of descent of the return flight. What made them performing worse is unclear. Sleep quality and total sleep time were sufficient, and subjective alertness was at a normal level. But, when considering both performance parameters during the return flight, one could explain this finding by the fact that older pilots might have payed more attention to the vigilance task while younger pilots have put more effort into the tracking task. One have to keep in mind that the differences found account for the comparison between the two age groups. When comparing tracking performance of the older pilots on out- and inbound legs itself, no significant differences were found. This indicates that performance within this age group is at a comparable level on both flight legs.

The age-related effects found in this study are confirmed by the regression computations. Tracking performance showed to be significantly affected by age, while vigilance performance was not. This finding is in accordance with the study of Tsang (12). Braune and Wickens (1) examined the performance of pilots in tracking tasks and found a significant correlation between tracking accuracy and experience, but not between accuracy and age. If piloting an aircraft is regarded as a task comprising a major tracking component, this result is hardly surprising. Training and experience probably reduce or offset any negative effects of age. How far these findings also apply for this study population, is difficult to answer. The data did not allow for a differentiation into 'experience sub-groups' because of a very high correlation that existed between age and experience (r = .923, p < .001).

Although in this study no significant relationship was found between age and sleep quality and quantity, literature provides consistent evidence that this relationship exists (1,2,3) The pilots in this study population did not show differences between sleep at home and sleep during stopovers; they might be well adapted to their work schedules and/or might have had adequate rest and sleep opportunities. As a result, stopover sleep was sufficient to made them recover, and to perform at an adequate level during the return flight. However, operational demands and personal factors (such as age) might affect pilot's performance in such a way that an adequate performance level is not always self-evident. Therefore, it is recommended to keep focussing on adequate rest and sleep opportunities for pilots so that they can recover from increased fatigue due to these factors.

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